INFUSING SERVICE-LEARNING PEDAGOGY INTO DESIGN THINKING MODULES FOR YEAR 2 ENGINEERING STUDENTS

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Abstract

In Ngee Ann Polytechnic, Service-Learning is defined as a course-based experience where students participate in a service project that allows them to apply discipline knowledge and skills to meet community needs. Furthermore, students should gain a broader appreciation of their discipline and greater civic responsibility through reflecting on the service experience.

The School of Engineering – Mechanical Engineering Division offers four courses and teaches design thinking concepts to Year 2 students. Students learn the principles and process of design thinking through projects that require them to propose and develop engineering solutions that address real life issues. The division also runs experiential learning activities for Year 2 students to raise their social awareness and appreciation of how engineering benefits the society. The induction programme was planned as a precursor to the design thinking modules. Naturally, the induction programme and design thinking modules became conducive platforms for the infusion of service-learning. To date, the development of service-learning-infused design thinking has undergone four runs. At the end of each run, feedback was gathered and used to plan activities for the subsequent run. This paper highlights the main challenges encountered, changes made and resulting outcomes in these four runs.

In general, the four major challenges were difficulties in finding suitable community partners, making the service activities relevant to the courses and staff readiness to use the service learning pedagogy. The first two challenges had to be addressed in tandem as the community partners provided the issues for the service activities. In this regard, the initial run focused largely on exposing students to a common social issue and neglected addressing its relevance to the courses. Nevertheless, the subsequent runs saw attempts made at bridging the gap between the service activity and course relevance. The issue of staff readiness was moderated by engaging service-learning practitioners to introduce the concept of service learning and equip them with relevant tools and skills. The training also provided opportunities for staff to co-create content.

Keywords: service learning, community-based learning, design thinking, engineering, discipline-specific

Introduction

The Service-Learning (S-L) pedagogical approach aims to leverage on community service to achieve clearly defined academic learning outcomes. The term “service-learning”, according to Giles and Eyler (1994), has a range of definitions. In Ngee Ann Polytechnic (NP), S-L was instituted as a signature pedagogy in March 2016 and is based upon the definition by Bringle and Hatcher (1996). In NP, S-L is described as a credit-bearing and course-based educational experience where students participate in an organized service activity that allows them to apply discipline knowledge and skills to meet identified community needs. Furthermore, students should gain further understanding of course content, a broader appreciation of their discipline and greater civic responsibility through reflecting on the service activity.

In 2014, prior to the institutionalisation of S-L, “Week 1 Induction Programme (IP)” was introduced to enhance the learning journey experiences of engineering students. Coincidently, the IP for Year 2 students bore elements of S-L with objectives of nurturing students’ social awareness and responsibility to make an active contribution back to society, helping students recap and refresh what they have learnt in Year 1; preparing them for Year 2 modules; and helping them appreciate engineering and its usefulness in the context of the larger society. Thus, the IP and S-L pedagogy adopted by NP share common student outcomes. Yet, the S-L pedagogy still required a credit-bearing module into which it could be infused. This came in the form of design thinking (DT) modules which were already the backbone of the IP.

The Mechanical Engineering (ME) Division exposes all Year 2 students to DT concepts through two credit-bearing modules (Tan, Lek, Chung, Ng, Tan and Tang, 2016). These DT modules were designed to be course-specific so as to allow students to apply the design thinking principles to projects relevant to their respective disciplines. ME Division offers four courses, namely, Automation & Mechatronic Systems (AMS), Aerospace Technology (AT), Mechanical Engineering (ME) and Marine & Offshore Technology (MOT), with an average Year 2 cohort of 620 students in 33 classes. In relation to the IP, these DT modules were used as scaffolds to frame and run the IP activities. Given the IP objectives of
helping students to appreciate the societal and real-world relevance and applications of engineering, the projects for the DT modules also took on a humanitarian engineering flavour. Nevertheless, it was only from the second run of IP onwards that the planning committee tapped on the synergies between IP, DT and S-L and infused S-L into IP and, consequently, the DT modules. Initially, S-L was used as a pedagogical guide in the design of IP activities so that students could gain a better appreciation of their course by addressing societal needs through proposing engineering solutions related to their discipline. Eventually, the institutionalization of S-L as a signature pedagogy led to a deeper infusion of S-L into the DT modules due to the pre-existing links between these 4 initiatives. The S-L/DT modules were first piloted in 2016 and then officially launched in 2017.

**Literature Review**

The synergies between S-L and engineering education has been documented by many researchers. Tsang (2000) advocated the use of S-L to educate students in technical and non-technical knowledge and skills as well as to develop their moral compass and professional disposition that will enable them to employ technology to address the societal needs and human aspirations of the 21st century. While S-L in engineering education is relatively established, a literature review revealed that the typical strategy of introducing S-L into engineering curricula tended to start on a small scale and then, in some cases, grew to a larger scale through voluntary adoption by newcomers. On the other hand, the mass implementation of S-L to a large cohort of students from the onset is not as well published.

Sevier, Chyung, Callahan and Schrader (2012) conducted a credit-bearing and project-based module on the engineering design process to engineering freshmen university students. Students worked on adaptive design projects for 1 semester that involved modifying or creating solutions for persons with disabilities. In all, 69 students completed 22 S-L projects over 2 semesters. In the first semester, 2 classes undertook 12 projects, while 2 more classes undertook 10 projects in the second semester. Huff, Zoltowski and Oakes (2016) reported on the EPICS program conceived by Purdue University to prepare students for the workplace by developing their skills in design, teamwork, leadership, communication and social awareness through focusing on community-based design. They highlighted that from its start in 1995 with 40 students, it now has about 660 students in 31 classes involved in over 90 design projects in each semester. In another S-L program, SLICE, for college level engineering at the University of Massachusetts Lowell, Duffy, Barrington, West, Heredia and Barry (2011) reported on the integration of S-L projects into required engineering courses throughout the curriculum so that each semester would have at least 1 S-L related course. The article stated that of the 32 courses offered in the academic year, 19 were engineering science related while the remainder were design and Year 1 introduction courses. On average, 753 students in each semester undertook S-L projects related to the subject matter of the course. In the same vein as most S-L initiatives, the program started small and gradually grew to its current form. One important factor that was credited to the growth of the SPICE program was the willingness of faculty members to, on their own initiative, integrate S-L in their courses.

Based on the results of research work reviewed, the apparent developmental trajectory of S-L programmes appear to begin as a small group initiative which grew in size and momentum either through an expansion of the original seed group or the sprouting of new groups. In this aspect, by implementing S-L to the entire cohort of Year 2 students from the onset, the development of S-L in ME Division has taken a non-traditional approach and has encountered unique challenges in its implementation.

This paper presents the implementation of IP over the years, the evolution of IP from a community-based project to a purposefully design S-L experience. The paper will also discuss the challenges faced during the implementation over the years, such as, finding suitable community partners, designing course-relevant service activities and staff readiness in S-L delivery.

**Implementation Process**

The infusion of S-L into the IP and DT modules has, so far, undergone 4 runs. With reference to the S-L programme in each run, as shown in Table 1, the implementation process is described below.

**IP2014**

The IP2014 planning committee comprised 5 DT lecturers. During planning, it was decided that the IP activities should be linked to DT modules as the modules were credit-bearing and this would ensure a healthy student participation rate. Moreover, these modules are taken by all Year 2 students, thus, allowing all students to have the experience of working with the community. A total of 36 facilitators were deployed to 33 classes for the IP. The facilitators’ role was to introduce DT to the students and supervise them during the IP. Of the 36 facilitators, 7 continued to teach DT to 11 classes after the IP. In each class, smaller groups of about 5 students were formed and assigned a persona to role play and 4 tasks to complete. To create a sense of realism, students had to use the appropriate equipment, such as, wheelchairs and crutches, for the role play and also perform the tasks at public venues. In order to minimise overcrowding at the venues, many locations had to be used and an ordered sequence of tasks planned for the groups to follow. Upon completion of the empathy experiences, students then worked through the remaining steps of the DT process and finally presented their proposed engineering solutions during a poster exhibition, which would mark the end of their IP project. In the following week, they would be given a course-related issue as their DT project, which was unrelated to the IP project.

**IP2015**

IP2015 was planned by the IP2014 committee. A total of 39 facilitators, of which 29 were involved in IP2014,
appreciation of their academic discipline. This resulted in giving them a sense of purpose in their project work, while developing their sense of civic-mindedness and means to address students’ motivation in learning, by interact with our students, WWS was engaged as they

<table>
<thead>
<tr>
<th>Year</th>
<th>Community partner</th>
<th>Mode of collaboration</th>
<th>Empathy activities</th>
</tr>
</thead>
<tbody>
<tr>
<td>2014</td>
<td>Nil</td>
<td>Nil</td>
<td>Role play a variety of scenarios where persons with mobility difficulties perform various tasks</td>
</tr>
<tr>
<td>2015</td>
<td>National Environment Agency (NEA)</td>
<td>Custodian of the Values in Action programme: Clean Singapore Learning Trail (Beaches)</td>
<td>Cleaning up recreational beaches in various parts of Singapore</td>
</tr>
<tr>
<td></td>
<td>Waterways Watch Society (WWS)</td>
<td>WWS presented a talk on marine pollution and its effects on marine life</td>
<td></td>
</tr>
<tr>
<td>2016</td>
<td>National Environment Agency / International Coastal Clean-up Singapore (ICCS)</td>
<td>• NEA is the custodian of the Clean Singapore Learning Trail (Beaches) programme • ICCS presented a talk on coastal pollution and clean-up</td>
<td>AMS students cleaned up recreational beaches</td>
</tr>
<tr>
<td></td>
<td>National Environment Agency</td>
<td>• Custodian of the “5 Step Mozzie Wipeout” initiative</td>
<td>AT students conducted house visits to advocate the message of preventing mosquito breeding</td>
</tr>
<tr>
<td></td>
<td>Waterways Watch Society</td>
<td>• Presented a talk on waterways pollution • Facilitated clean-up activities in and around the waterways</td>
<td>MOT students went on a learning journey cum clean-up on foot, bicycles and kayaks</td>
</tr>
<tr>
<td></td>
<td>Ngee Ann Polytechnic Wheelpower Club / Wheelchair Basketball Association (WBA)</td>
<td>• Volunteers from Wheelpower Club interacted with our students • Representative from Wheelchair Basketball Association gave a talk on mobility issues</td>
<td>ME students role played as wheelchair bound persons to perform various tasks at housing estate town centres</td>
</tr>
<tr>
<td>2017</td>
<td>Waterways Watch Society</td>
<td>• Presented a talk on coastal pollution • Facilitated beach clean-up activities</td>
<td>AT students went on a learning journey cum beach clean-up exercise</td>
</tr>
<tr>
<td></td>
<td>Waterways Watch Society</td>
<td>• Presented a talk on Singapore’s water sustainability story • Facilitated clean-up activities in and around the waterways</td>
<td>Students surveyed waterways to monitor the level of cleanliness and understand existing measures used to maintain cleanliness</td>
</tr>
<tr>
<td></td>
<td>All Saints Home (ASH)</td>
<td>• Needed volunteers to entertain their patients with game and craft activities • Needed volunteers to bring patients to and from the activity area</td>
<td>AMS students brought patients around in wheelchairs and interacted with them through games and craft activities</td>
</tr>
<tr>
<td></td>
<td>Disabled People’s Association (DPA)</td>
<td>• Presented a talk on inclusivity and barrier free access for the disabled • Organised activities to help our students understand about disabilities</td>
<td>ME students took part in a simulated handicap experience to identify barrier free access issues within and around NP campus</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Students interacted with DPA volunteers to hear first-hand accounts of disability issues</td>
</tr>
</tbody>
</table>

Table 1: Service-learning programme across the 4 runs.

were deployed. Of the 39 facilitators, 8 continued to teach DT to 11 classes. At the planning stage, the committee decided to use S-L as a pedagogical guide for activity design so as to enhance learning experiences and better achieve the programme objectives. S-L was chosen since it advocates the use of community service activities as a means to address students’ motivation in learning, by giving them a sense of purpose in their project work, while developing their sense of civic-mindedness and appreciation of their academic discipline. This resulted in the inclusion of several new features in IP2015, such as, the involvement of community partners, a common service activity related to the mission of the community partners and sessions for reflective learning.

Singapore’s NEA was chosen as a community partner that needed assistance in addressing coastal pollution. However, as NEA could not provide stakeholders to interact with our students, WWS was engaged as they were experienced and able to partner us for this purpose. WWS is an environmental non-profit organisation whose mission is to form communities of people who are dedicated to the protection of Singapore’s waterways. Their outreach efforts include conducting talks on environmental issues, organising and facilitating waterway clean-up activities. Through their sharing, students became aware of WWS and its social mission, and could associate a beneficiary to their beach clean-up efforts. During the service activity, apart from litter picking, students were also instructed to conduct the DT empathy exercise in relation to their respective courses’ area of focus. While at the beach, students had to answer a questionnaire that guided them in reflecting on their experiences. The questions helped them to reflect on what they observed during the activity, the end result of the activity and what more could be done to improve the service. These reflections would be presented together

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with information on the social cause and their proposed engineering solutions, developed using the design thinking process, in a poster exhibition. As the IP projects had been crafted with course-related problem statements, students continued working on these projects for DT, which helped link the S-L in IP to DT.

**IP2016**

For IP2016, a new planning committee was formed which included the S-L coordinator and the 4 DT MLs. The inclusion of these stakeholders facilitated planning and alignment of IP service activities to DT projects and ensured greater course relevance in the service activities. The search for community partners and collaboration arrangements were done by the S-L coordinator while the MLs advised on the DT projects and developed the problem scenario based on the profile of the partners and services rendered.

For better student engagement and sense of continuity from IP to DT for the students, all 34 IP facilitators were trained in S-L tools and facilitation skills. Furthermore, 22 of the facilitators would eventually be teaching the DT modules to 30 classes. In addition, the empathy process of DT, which would be taught and applied in the IP, was also refined into 5 process steps, namely, Investigate, Prepare, Act, Reflect and Demonstrate.

In “Investigate”, students framed the social issue and identified stakeholders involved. The identification of stakeholders would help to raise students’ awareness of the human element of the issue. As part of “Investigate”, volunteers from our community partners were engaged to give talks and interact with our students to further reinforce the human element. In “Prepare”, students planned tasks, assigned roles and prepared interview questions for the service activity. In “Act”, students performed the service activity and recorded data for their DT projects. For IP2016, only MOT students performed the service activity with volunteers from WWS and thus experienced sustained interactions with them. Students from the other courses were led by their facilitators and only interacted with stakeholders sporadically during the service activity. In “Reflect”, students recalled, recorded and shared their individual observations from the service activity as well as their personal experiences and thoughts. In “Demonstrate”, students worked in groups to create and present a poster that captured their S-L journey and also highlighted its links to their DT projects. This gave students the chance to form links between their service activity and DT project, thereby giving them a sense of continuity from IP to DT. As in the earlier runs, the poster presentation cum exhibition marked the end of the IP.

**IP2017**

The IP2016 committee was retained to plan IP2017. While the search for community partners was still done by the S-L coordinator, discussions on collaboration modes now involved the MLs as well. In this approach, after the initial contact and confirmation with community partners, planning of service activities and discipline-specific projects were done concurrently. This gave MLs the opportunity to work directly with the community partners to plan the service activities and also helped them to develop their DT projects so that it could link better to the IP activities. In addition to service activities, the S-L coordinator and MLs also had to conceptualise and plan an extra activity for the IP which would serve as an additional empathy experience for the students. This was done so as to give students another opportunity to appreciate the social issues to be addressed. As a result of the additional empathy activity, the application of the 5 process steps of empathy extended beyond the IP into the first DT lesson. Consequently, the main focus of the IP activities was to identify the stakeholders, experience issues from their perspective and reflection. In the following DT lesson, students looked at future implications and documented their findings. As such, the poster exhibition, which traditionally marked the end of IP, was not conducted but replaced with a class level sharing of findings and reflections. In this way, the continuity from IP to DT was enhanced and the link between service activities to DT projects further strengthened. Thus for IP2017, students from all 4 courses enjoyed more sustained interactions with stakeholders. This enhanced the students’ connection with stakeholders and helped augment the stakeholder identification exercise in “Investigate” which would better reinforce the human element of the social issue to students.

**Challenges during Implementation**

The challenges faced in the implementation of S-L across the 4 runs can be categorised into 4 areas:

1. Suitable community partners
2. Designing course relevant activities
3. Staff preparation

**Suitable community partners**

The challenges of finding suitable community partners were attributed to factors such as the scale and scope of their service activities which could engage a large number of students and be relevant to the course disciplines; and their ability to provide stakeholders associated to their social cause who could share experiences and interact with our students.

The large cohort size of 620 students across 33 classes posed a challenge to finding a sufficient number of community partners who could, collectively, embody a common social cause and provide an opportunity for all students to be engaged meaningfully during the week. To circumvent this challenge, in IP2014, it was agreed that students would be exposed to a common social issue through purposefully designed community-based learning activities that should present opportunities for students to practise the DT concept of empathy rather than through community engagement. This meant that students were not able to experience S-L in this year’s implementation. In IP2015, the challenge was mitigated by using government-run initiatives, which include activities with societal-oriented themes. Specifically, Singapore’s NEA was chosen as a community partner as they had readily available programmes, designed for student participants, which focused on national
campaigns that our students were familiar with. Furthermore, the challenge of finding a common service activity for the entire cohort was made less daunting due to the availability of several recreational beaches that could accommodate our large number of students for a beach cleaning service activity. In IP2016 and IP2017, multiple S-L themes were used instead of a single common theme. This removed the constraints placed on selecting only one community partner or a group of partners with common social causes who could cater to a large student cohort.

Another challenge of finding suitable community partners arose from the mismatch between partners’ expectations and students’ capabilities. More often than not, the desired solutions to issues faced by community partners, which involved the application of course relevant knowledge, required a level of technical competence that is above the capabilities of our fresh Year 2 students. This mismatch also limited the scope of course-relevant service activities that our students could engage in and thus posed a challenge when designing these activities.

**Designing course relevant activities**

The challenges of designing course-relevant service activities stem from a broad set of requirements such as meeting both our needs and that of community partners, ensuring that service activities adequately expose our students to social issues and raise their level of awareness as well as framing the service activities in a context that will enable students to link the service activities to their course disciplines. As mentioned earlier, the mismatch of required technical competence to develop meaningful solutions for the community partner and the engineering knowledge of fresh Year 2 students presented constraints in the choice of service activities. Thus, instead of choosing service activities that needed sophisticated technological solutions to be implemented, service activities with little or no technological requirements were chosen. The challenge, then, was to craft problem scenarios based on the service activities that will help students to appreciate the course-specific technological solutions used in addressing the social issues concerned. Moreover, these service activities were designed as opportunities for students to empathise and interact with stakeholders associated to the issue so that they became empathy experiences for the DT modules. As such, the link between service activities and course curricula was maintained.

In IP2015, where a common theme on coastal pollution was used by all 4 courses, it was necessary to develop various scenarios around the same service activity to highlight the contributions of various course disciplines in providing solutions for the same social issue. In IP2016 and IP2017, with the engagement of a few community partners, more flexibility in designing a variety of service activities with links to the various course disciplines was possible.

**Staff preparation**

There was a need to train staff as it would be a challenge for them to conduct S-L during the IP without prior knowledge or experience in it. The purpose of having staff training was to inform staff on the NP S-L initiative, enable staff to deliver the S-L programme effectively, engage staff in content creation and provide an avenue for staff to give feedback and suggestions in programme development.

To implement this, S-L practitioners who have guided youths were engaged as training providers. The training covered content, such as, social issues, S-L tools and facilitation methods that were relevant to the IP. Staff were exposed to the S-L concepts and tools to induct students into their S-L projects, envisage issues from multiple perspectives and help students reflect on their S-L experiences. By practising the use of these tools and facilitation techniques on relevant social issues, facilitators were able to familiarise themselves with the tools, create resources for the IP and anticipate queries from students. The training also served as a forum to clarify doubts and gather suggestions and feedback from facilitators. Skills training aside, staff were also briefed on NP’s S-L pedagogy and updated on the proposed service activities and DT projects. During the update session, staff also reviewed and suggested enhancements to the proposed activities and overall programme flow.

The distribution and profile of facilitators over the 4 runs are shown in Figure 1. It can be seen from “IP Faci experienced” that 50% ~ 89% of IP2015 facilitators were involved in IP2014. All IP2016 facilitators were S-L trained, but the percentage of facilitators who had prior experience in IP fell to 25% ~ 86%. The percentage of IP2017 facilitators trained in S-L was 25% ~ 100% due to the fielding of MOT facilitators who received limited S-L training. Moreover, only 50% of MOT facilitators had prior IP experience. These changes in the distribution and profile of S-L facilitators would have impacts on S-L programme delivery and students’ S-L experience.

![Figure 1: Distribution and profile of S-L facilitators.](image-url)
Impact of S-L IP Experience on Students

Developments in infusing S-L into IP and linking IP to DT were tracked through IP student survey results. The questions concerning the suitability of community partners and service activities, and the readiness of staff in facilitating the S-L programme were:

1. The IP has given me an opportunity to raise my social awareness; and
2. The IP has helped me to appreciate the relevance of engineering to society.

Question 1 would indicate whether the type of service activities, mode of collaboration, use of S-L tools and enhancements to the empathy experience raised students’ perception of gaining greater social awareness. Question 2 would indicate whether attempts to link the IP service activities to DT projects through activity design and scheduling and facilitator deployment enabled students to realise that social issues could be addressed through applying engineering skills.

Comparing the ME results, as shown in Figure 2(a), for IP2014, IP2016 and IP2017 when students addressed the social issues related to mobility of the disabled, it can be noted that positive responses (comprising SA and A) for both questions increased from IP2014 to IP2016. This coincided with the engagement of a WBA speaker and the implementation of S-L tools, 5-step empathy process and S-L trained facilitators. From IP2016 to IP2017, the extra empathy experience with DPA volunteers led to a rise in the proportion of students responding SA.

As shown in Figure 2(b), the MOT results for IP2015 and IP2016, when service activities involved WWS, rose in positive responses for question 1 with the introduction of S-L and DT enhancements. However, the negative responses (comprising D and SD) for question 2 also rose indicating that students could not see the link between the service activity and course discipline. A possible reason could be that in IP2015, a strong storyline linked the service and course discipline as all students participated in beach cleaning. In IP2016, however, some service activities, such as, bicycle and foot patrols could not be strongly linked to the course discipline. In IP2017, besides replacing the bicycle and foot patrols with waterways cleaning in kayaks, the additional empathy experience of identifying the origins of waterways litter was included. However, the positive responses for both questions suffered a drop in IP2017. Apart from a possibility that the additional empathy experience was not well received by students in terms of raising social awareness.
awareness, another possible cause could be the fielding of less experienced facilitators.

As shown in Figure 3(a), the AT results for IP2015 and IP2017, when service activities involved WWS, rose in positive responses for both questions. Furthermore, the proportion of students responding SA also increased. While both MOT and AT students participated in service activities involving WWS, the more positive response from AT students may be attributed to the fielding of more experienced facilitators for programme delivery.

As shown in Figure 3(b), the AMS results for IP2015 and 2016, when service activities involved WWS and NEA/ICCS, respectively, rose in positive responses for both questions. While the mode of collaboration with WWS and ICCS were similar, the IP2016 programme was enhanced with S-L related features, which may be attributed to the more positive responses.

Conclusions

The development trajectory of S-L in ME Division took a non-conventional approach compared to most S-L initiatives. As a result, deliberate steps had to be made to infuse S-L into the curriculum for the entire cohort of Year 2 students across 4 diploma courses. Through the 4 developmental runs, 4 major factors were considered as being instrumental to the effective delivery of the S-L experience to students, namely, suitable community partners, course-relevant service activities and staff readiness. The search for suitable community partners and design of course-relevant service activities are interrelated and should be handled by a team comprising S-L and academic content representatives in order to arrive at service activities that are beneficial to both the community partners and the students. Given that the S-L programme delivery will ultimately depend on the facilitator, it is important to equip staff with usable S-L tools and appropriate facilitation skills for effective delivery and meaningful student learning experience. Currently, the service element of the service activities undertaken by ME students is still not strong and would require further enhancements in the subsequent runs. In addition, the need to train all lecturers in the S-L pedagogy and for all lecturers to be given the opportunity to facilitate the S-L programme on a regular basis should also be addressed, so as to build up staff capability in delivering S-L.

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References


